Pediatric Cochlear Implantation

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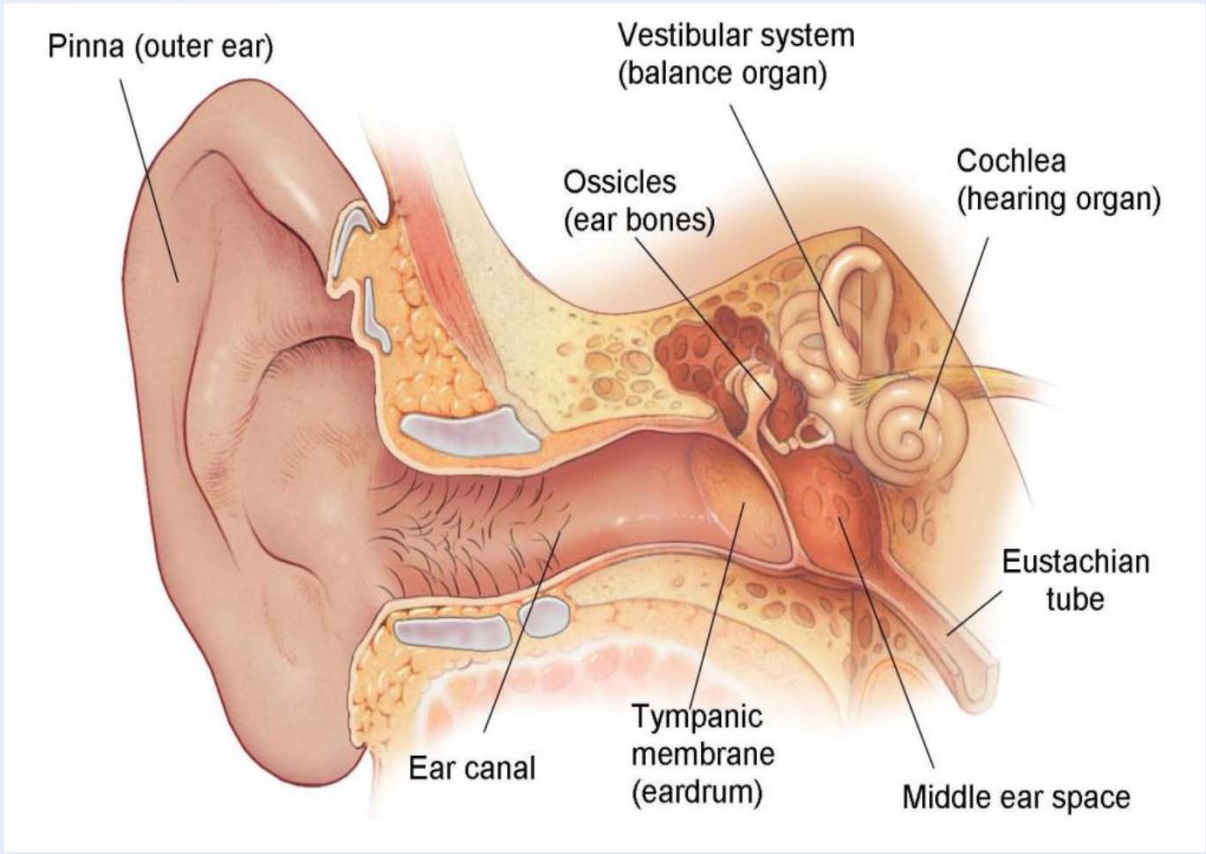
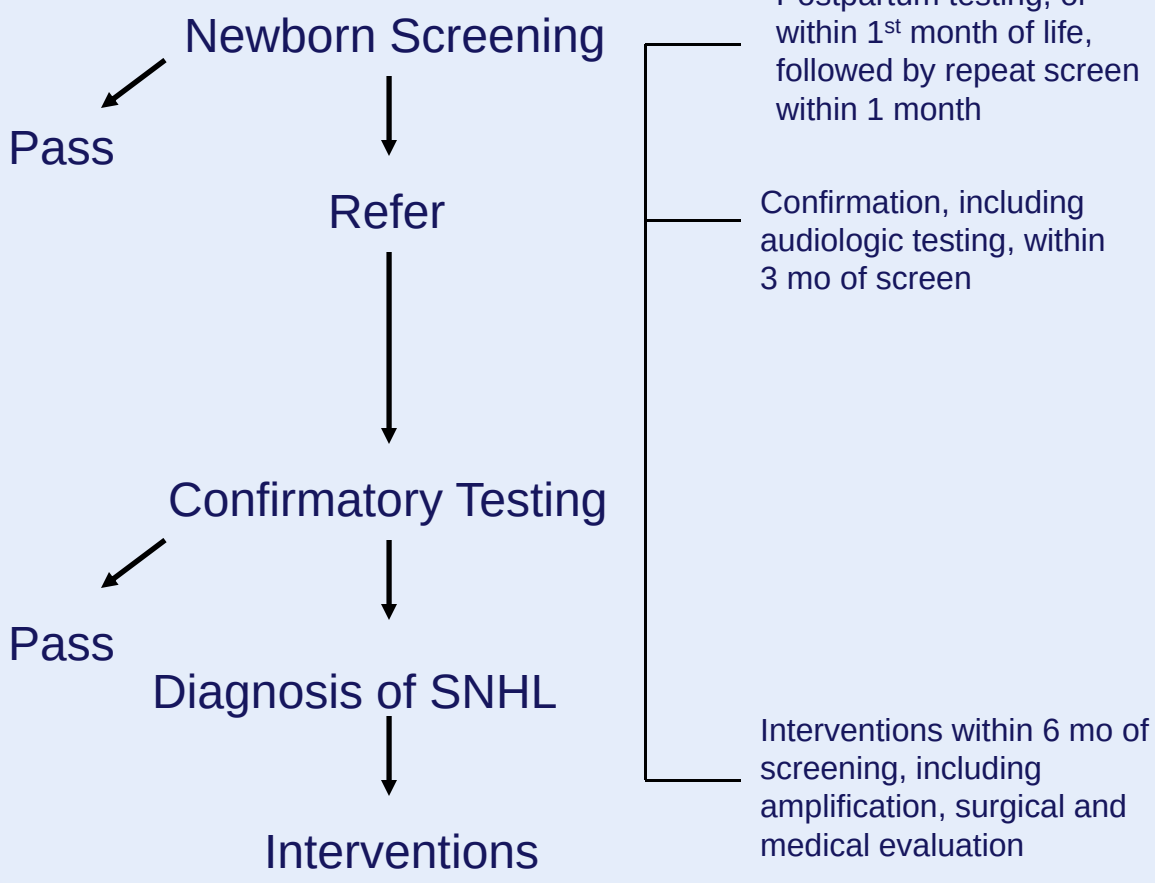
Objectives

- Overview of Hearing
- Principles of cochlear implantation
- Specific needs of cochlear implant patients
- Modern advances
- Future trends



Wikipedia.com

Hearing Screen



History CI

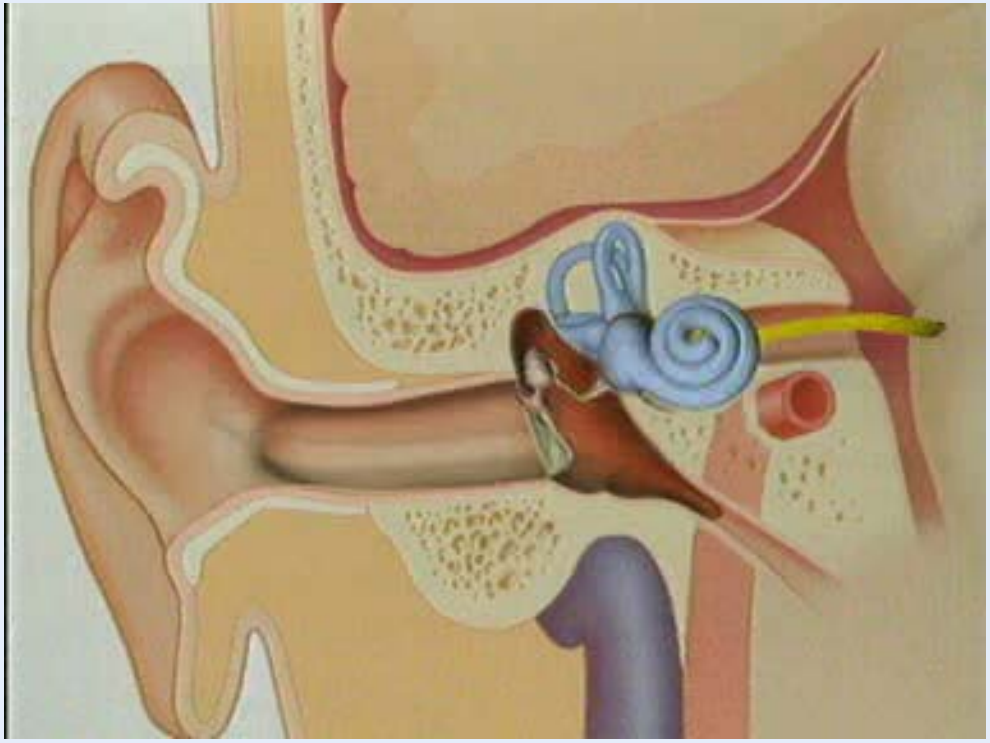
- **18th century** *Volta 1800*
  - **Alessandro Volta**
    - **Discovered electrolytic cell**
    - **Stimulated auditory system**
      - **Connected a battery with 2 metal rods to his ears**
      - **“une recousse dans la tête”** Epstein:1989: 34
      - **Sensation was momentary and lacked tone**

New Era

- House (1976) and Michelson (1971)
  - Scala tympani implantation of electrodes
    - House implanted several devices
      - Worked for short time
      - Rejected due to lack of biocompatibility
  - House teamed with Jack Urban (engineer) to make cochlear implants a reality
    - 1972
      - Speech processor was developed to interface with House 3M single electrode implant
      - First to be commercially marketed

Cochlear Implant

- 2 parts
  - External
    - Microphone
    - Speech processor
    - Transmitter
  - Internal
    - Receiver
    - Stimulator
    - Electrodes



www.cochlear.com

1st Implants in Children

- 1977, France
  - Claude-Henri Chouard implanted 2 kids
    - 10 years and 14 years
  - Implants met with significant resistance from the deaf community world wide

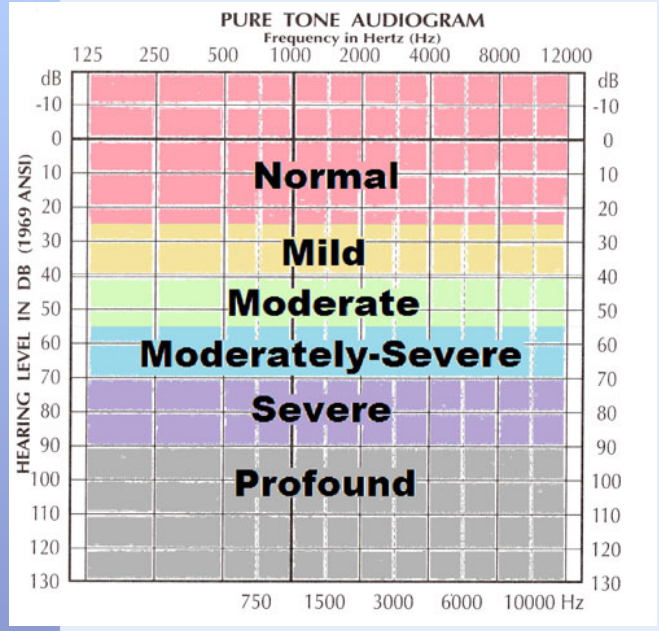
Pediatrics

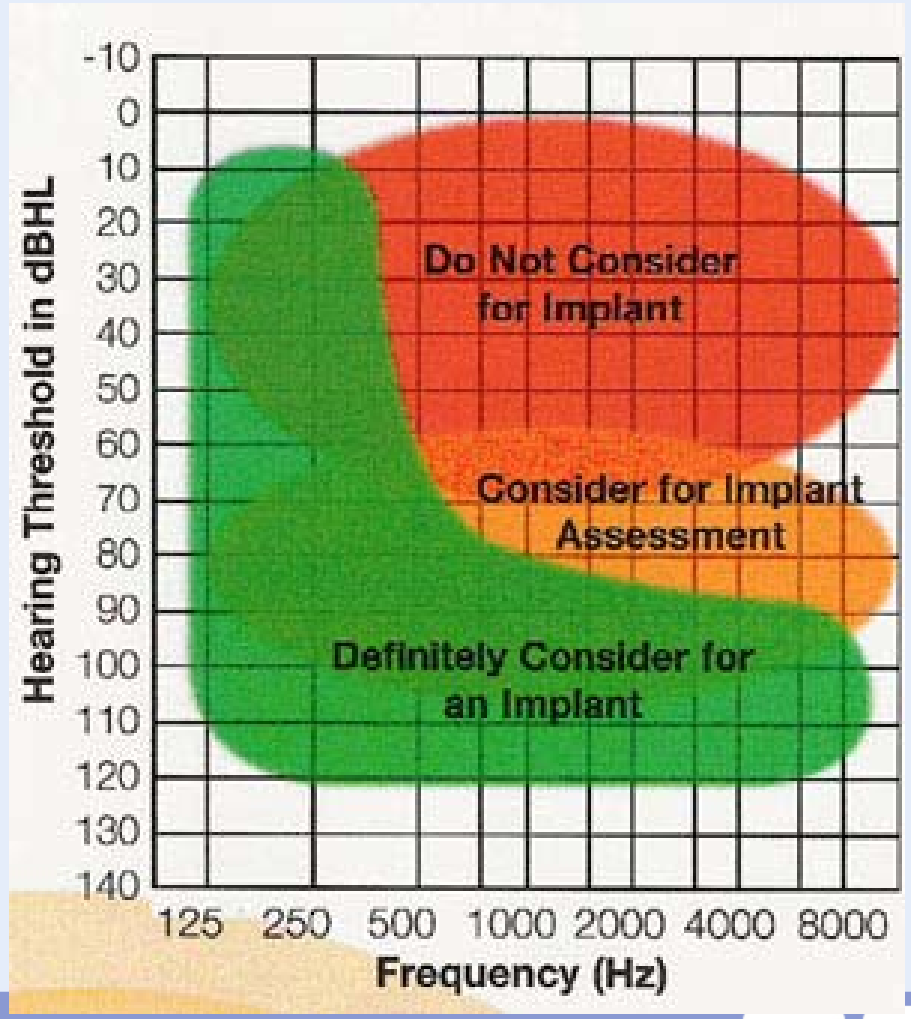
- 1980
  - FDA allows children ~ 2 to be implanted
  - 1998: age limit dropped to 18 mo
- Currently
  - Age limit 12 months
  - Advanced bionics, Med-El, Cochlear corp.
- Over 70,000 implants world wide
  - Over 50% are children

Pediatric Indications

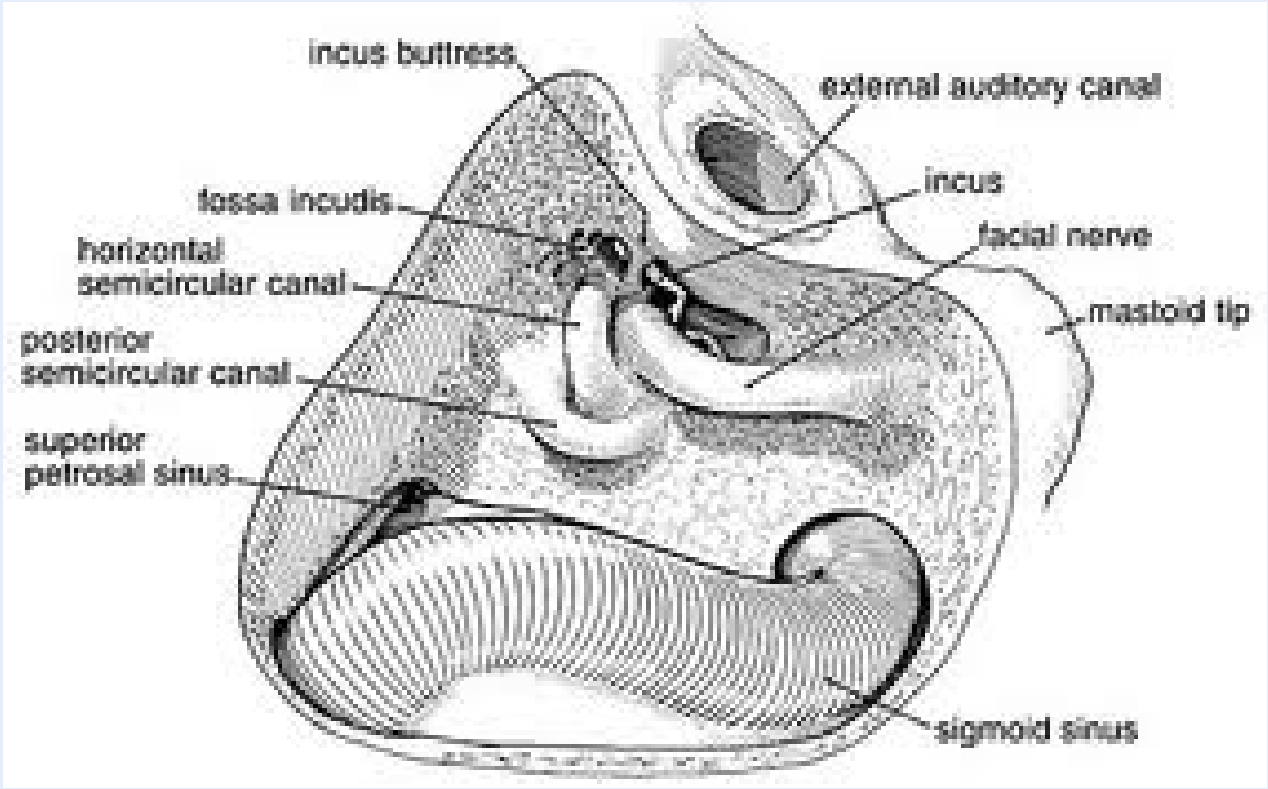
- **1980s: Bilateral tonal deafness >110 dB HL**
  - **1990s: Severe hearing loss >70dB HL**
  - **Current: <50% open-set sentence recognition with properly fit HA**

Pediatric Indications





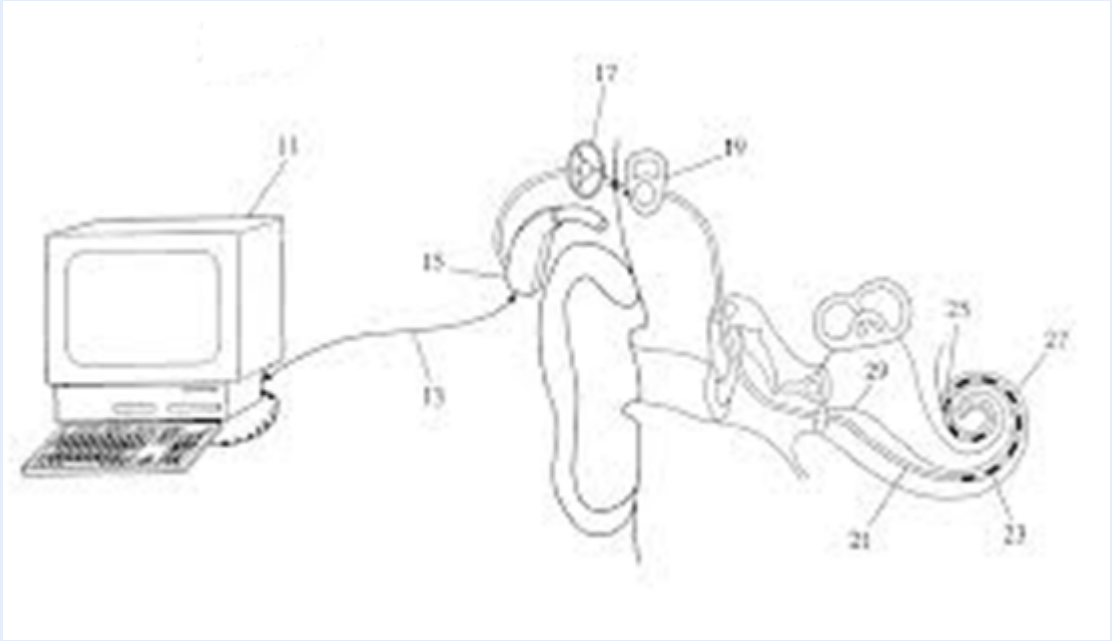
CI Surgery


incus buttress
external auditory canal
incus
fossa incudis
facial nerve
horizontal
semicircular canal
mastoid tip
posterior
semicircular canal
superior
petrosal sinus
sigmoid sinus

CI Surgery

Intraoperative Testing

- **Neural Response Testing**



Activation

- Unique unforgettable experience
- 2-4 weeks postoperative
- Goals
  - Comfort
  - No Fear
  - Soft whisper
- Very careful in children

Programming

- Mapping
- Several visits
- T-level
- C-level

Case

- 6 month male
- Full term normal vaginal delivery
  - Failed NBS
  - Failed repeat NBS
  - Diagnostic testing
    - Bilateral profound SNHL
  - Bilateral HA

Outcomes

- **4 factors are of primary importance in CI patients**
  - **Age at onset of deafness**
  - **Duration of deafness prior to implantation**
  - **Progression of hearing loss**
    - **Residual hearing**
  - **Educational setting**

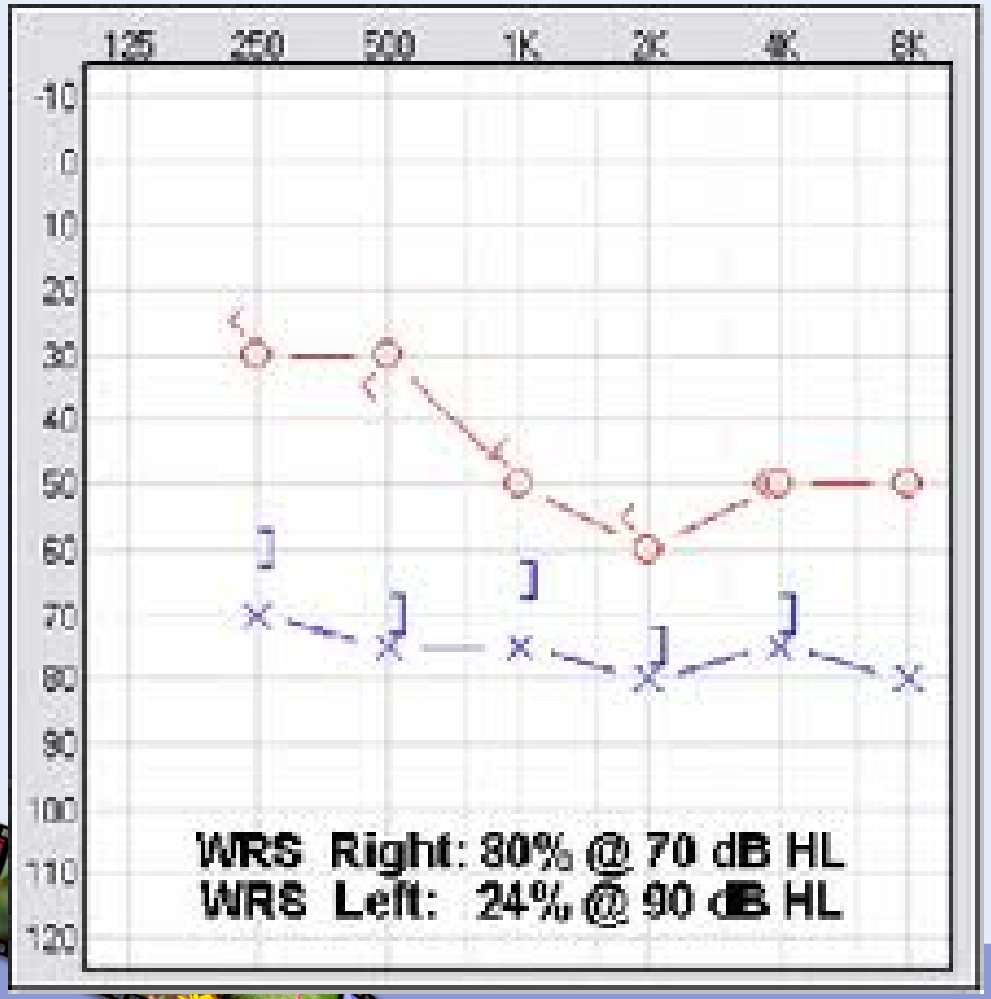
Ideal Candidate

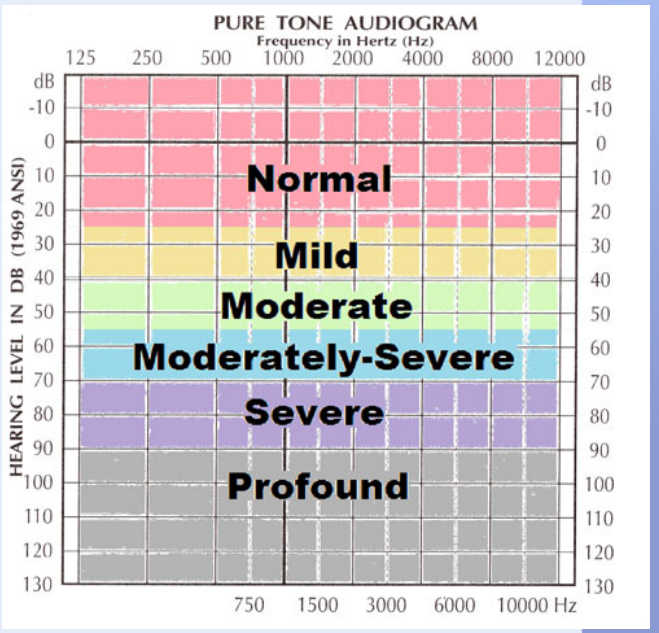
- Severe to profound SNHL in both ears.
- Functioning auditory nerve
- Lived at least a short amount of time without hearing
- Infants and young children: family willing to work toward speech and language
- Older children: good speech, language, and communication skills,
- Minimal benfit from other kinds of hearing aids
- No medical reason to avoid surgery
- Living in or desiring to live in the "hearing world"
- Realistic expectations about results
- Support of family and friends
- Appropriate services set up for post-cochlear implant aural rehabilitation

Case

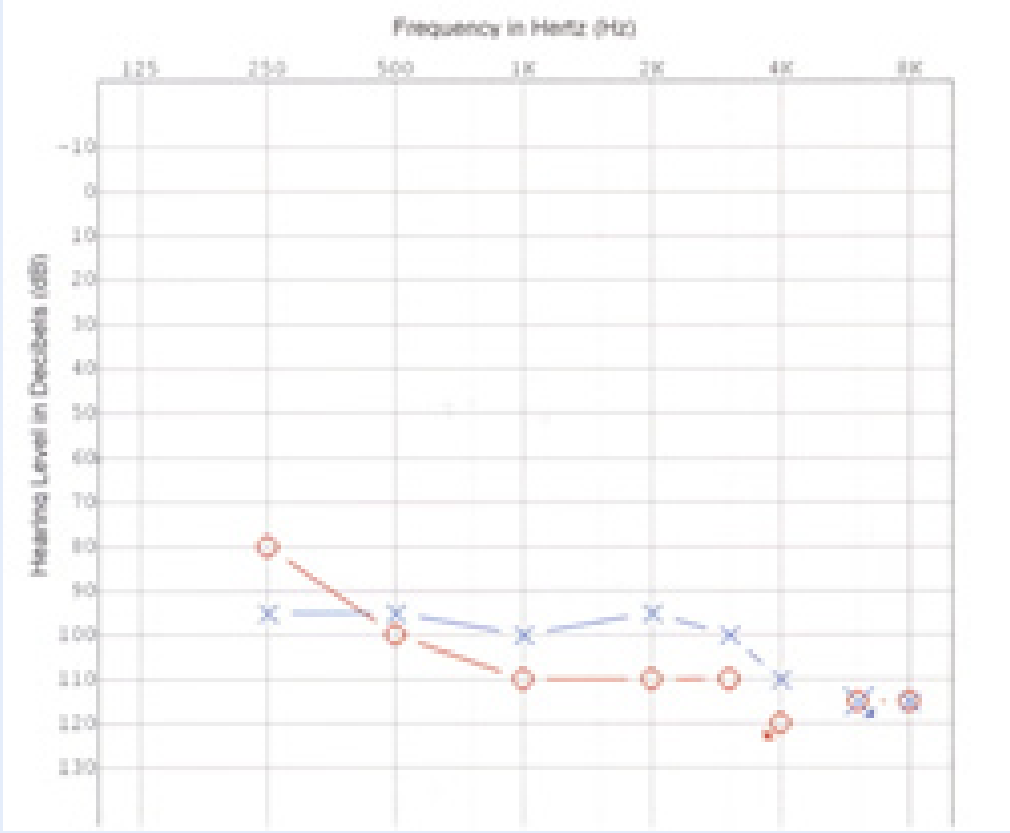
- 16 year old female
- Complaint: bilateral hearing loss
  - Passed NBS
  - Diagnosed at 2 with left hearing loss
  - Having trouble at school
  - No family history of hearing loss
  - No history of trauma, IV antibiotics
  - Very healthy: no surgeries etc

Audiogram


125
250
500
1K
2K
4K
8K
-10
0
10
20
30
40
50
60
70
80
90
100
110
120
WRS Right: 80% @ 70 dB HL
WRS Left: 24% @ 90 dB HL


PURE TONE AUDIOGRAM
Frequency in Hertz (Hz)
125 250 500 1000 2000 4000 8000 12000
dB
-10
0
10
20
30
40
50
60
70
80
90
100
110
120
130
HEARING LEVEL IN DB (1969 ANSI)
Normal
Mild
Moderate
Moderately-Severe
Severe
Profound
750 1500 3000 6000 10000 Hz

6 months later…



Controversy

Deaf Advocacy

"social-cultural"

- **ASL is defining language**
- **Minority culture, diminution** Balkany, Hodges, & Goodman, 1996
- **Being deaf is single most defining event**
- **Values to be taught by culturally deaf adults**

"medical-disability"

- **Failure to achieve an expected level of function** Engelhardt 1996
- **$121 billion spent annually on education** NIH consensus statement
- **Cochlear implantation: the earlier the better**

Children with Disability

- **Outcomes with children who are deaf are *NOT* transferable to children with disabilities**
- **Effect of hearing loss is underestimated**
- **Superior benefit with earlier implantation**

Disability

- **Cons** Bertram (2004)
  - **Increased complexity**
  - **Increased counseling especially about limitations**
- **Pros** Bertram (2004)
  - **Environmental stimulation for development**
  - **Awareness of potential dangers**
  - **Develop greater autonomy**

Socioeconomic Disparity

- **Substantial differences in rates of implantation** Holden-Pitt, 1998; Stern et al. 2004; Fortnum, et al., 2002
  - **Race**
    - **Caucasian and Asian-American 5X higher than Hispanic-American; 10X higher than African-American** Stern et al. 2004
  - **Socioeconomic status**
    - **More implanted children live in zipcodes with above-average median incomes** Holden-Pitt, 1998
  - **Presence of additional disability**
    - **15% versus 20%** Holden-Pitt, 1998

Ear Selection

- **Preoperative functional status**
  - **Hearing sensitivity**
  - **Speech perception**
  - **Better residual hearing = superior speech recognition**
- **Clinical status of the ears**
- **Anatomic status of the ears**

Ear: Right or Left?

- **Right ear advantage** Gadea et al 1997
  - **Left hemisphere dominant for speech and language processing**
    - **As young as 4 days old** Bertoncini J et al. 1989
  - **Contralateral auditory pathway stronger**
  - **Children with right HL more at risk for academic difficulty** Oyler et al 1998

Ear: Right vs Left

- **Henkin et al 2008**
  - **71 prelingual deaf, < 48mo, 30 right, 41 left**
  - **Small but significant right ear advantage**
- **Functional MRI** Henkin Y et al 2004
  - **Right CI similar to normal hearing**
  - **Left CI similar to unilateral deafness**

Bimodal Hearing

- **Multichannel implant for profound SNHL = hearing aid for severe loss** Geers AE et al, 1994
- **Bimodal: CI + HA**
- **Benefits** Clark GM et al 1999; Ching TY et al 2004
  - **Better sound localization**
  - **Improved hearing in noise**
    - **But still much worse than hearing patients**
  - **Improved head shadow**
  - **Loudness summation**

Future Advances

- Smaller device
- Completely implanted device
  - Battery issues
- Less traumatic surgery
- Minimally invasive surgery
- Thinner electrodes
- Insertion sites into the cochlea

Who pays?

- 1 CI
  - Most insurance companies
- 2nd CI
  - Denied by most insurance companies
- CHAP program
- Hearing Foundation

Cost

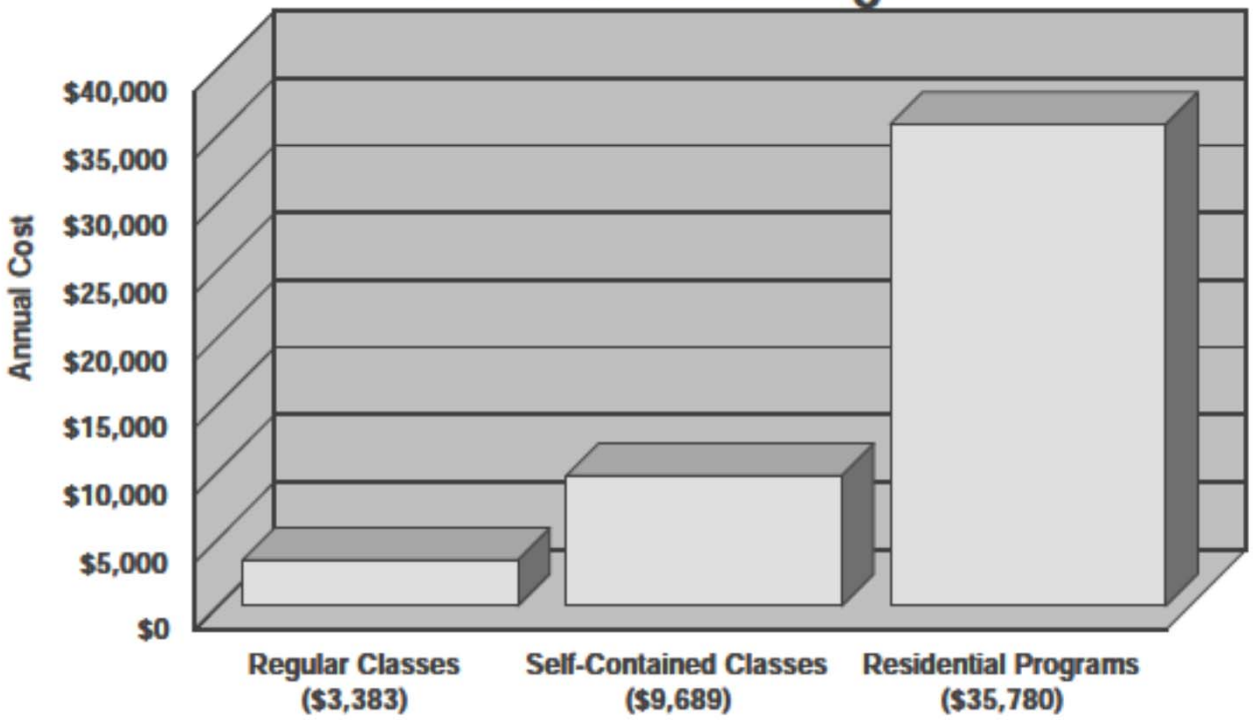
- **Medical costs**
  - **$45,000 to $125,000**
  - **Includes**
    - **Evaluation**
    - **Surgery itself**
    - **Hardware (device)**
    - **Hospitalization**
    - **Rehabilitation**

Children's Hospital

- 1st surgery
  - 10/31/2007
- Total 108
- Following 162 kids

Year	Surgery #
2007	3
2008	11
2009	16
2010	25
2011	26
2012	27

Cost of Educating Children with Hearing Loss in Various Settings



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Special Needs

- Immunizations
  - CDC guidelines
  - Pneumovax
- MRI restrictions
  - None for CT or plain films
- Static
  - Plastic playgrouds
  - Balloons

Special Needs

- **Trauma**
  - **Contact sports**
- **Metal detectors**
  - **Bracelets**
- **Zinc batteries**
  - **Choking hazard**

Team Approach








Conclusions

- **Cochlear implants are amazing**
- **Lot to learn & understand**
- **Continued research…**

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CHILDREN'S HOSPITAL

Turn On My Ears!

LSU